January 12, 1865.

Major-General SABINE, President, in the Chair.

The following communications were read :—

I. "Account of Observations of Atmospheric Electricity at King's College, Windsor, Nova Scotia."—No. II. By JOSEPH D. EVERETT, M.A., F.R.S.E., Professor of Mathematics in King's College, N.S. Communicated by Professor WILLIAM THOMSON, F.R.S. Received December 21, 1864.

My former paper* embraced the six months from October 1862 to March 1863. Since the latter date my observations have been continued as before, the water-dropping method being employed until December 1st, since which time burning matches have been used, as in the previous winter.

The glass fibre of the station electrometer remained unchanged till July 31st, when it became loosened from its attachment, and was replaced by a new and much thinner fibre, which has continued in use ever since. From comparisons made with the portable electrometer, in the manner described in my former paper, it appears that the change of fibre has increased the indications in the ratio of 20·2 to 3·1.

The principal observations have, as before, been made three times a day, namely at 8 or 9 A.M., 2 P.M., and 9 or 10 P.M.; but additional observations have frequently been taken at other hours, especially during the months of May, June, and July, when they were much more numerous than in any month included in the former paper. Each observation has generally contained five air-readings—the interval between the readings being a minute, until September 16th, since which date it has been only half a minute. I assume that this change cannot affect the mean result, though it may to some extent influence the observed range. It was adopted for convenience, the new fibre being found to admit of more rapid observation than the old.

The following is a summary of the results of observations during rain or other downfall, fog, and thunder and lightning—the period included being the eleven months from April 1863 to February 1864.

Rain.—With light rain the electricity is generally moderate, sometimes very weak, and sometimes about double the average fair-weather strength. These remarks do not apply to light rain immediately following heavy, the electricity being often as strong during the intervals between heavy rain, and for some time after its conclusion, as during its descent. Very heavy rain is almost invariably accompanied by very strong electricity.

Snow.—Almost always positive, but occasionally a little negative intermixed with positive; and on one solitary occasion (February 16th) strong negative sparks were drawn during a heavy fall of snow. On this occasion strong positive electricity was also observed. It is worthy of remark that

* Read June 18, 1863, Proceedings, vol. xii. p. 683.

on the following morning and midday strong positive sparks were drawn, and the electricity continued very strong positive during the remainder of the day. No snow fell, but a strong west wind filled the air with drifting snow.

Hail.—I have nothing to add under this head, except that on one occasion (February 26th) strong positive sparks were drawn during hail accompanied by lightning and thunder.

Sleet.—One observation: rather strong negative.

Fog.—Always positive, and generally above the average strength, but sometimes rather below. The fogs embraced in this account were few and inconsiderable, never lasting more than a few hours, whereas the former paper included some of a more decided character.

Thunder-storms.—None of these occurred during the period embraced by the former paper; but there have been several since, and always marked by very strong electricity.

The first occurred June 15th, distant thunder commencing about 1 P.M., and a violent thunder-storm continuing from $4^h\ 30^m$ to 6^h P.M. with a deluge of rain, three-quarters of an inch falling in half an hour. Silent lightning continued all the evening, and to an unknown hour in the night. The electrometer showed, as usual, moderate positive, while the thunder was distant; but observations from $4^h\ 36^m$ to $6^h\ 2^m$ showed electricity excessively strong, with frequent changes of sign. The extremes were +104 and −121, the average fine-weather strength being 3 or 4.

The next storm occurred June 24th. Observations were taken from $5^h\ 11^m$ to $5^h\ 39^m$ P.M., during which time much thunder was heard, but no lightning seen. The electricity observed was constantly negative, increasing by a nearly regular advance from −29 to −214, this last being the strongest electricity that I have ever yet found. No rain fell during this observation, but ·39 of an inch fell before 9 P.M., with some heavy peals of thunder and vivid lightning. Immediately after the heaviest peal strong negative electricity was found, but was not measured.

On the evening of July 6th there was much silent lightning, the flashes being at the rate of four or five a minute, some of them very vivid. The electricity observed was weak, never rising higher than 1·8.

The next storm occurred July 18th, and closely resembled that of June 15th, but on a reduced scale as regarded its external features. The indications of the electrometer, however, were quite equal in strength to those observed on that occasion. The next day (July 19th) there was distant thunder and lightning, with what appeared to be rain in the distance, from about 3 to 4 P.M.; and the electricity observed was very strong negative, observations extending from $3^h\ 11^m$ to $3^h\ 57^m$. The observations on these two days are given *in extenso* at the end of this paper.

Silent lightning was observed on the evening of August 6th, the electricity indicated being moderate positive.

On August 10th there was a deluge of rain with some thunder and light-

ning, during which frequent observations were taken, showing very strong electricity, generally negative.

No more instances occurred till the evening of February 26th, when hail fell, with short intermissions, from a little before $9^h\ 30^m$ P.M. till after midnight, accompanied by much lightning and some thunder. The only observation of the electrometer was at $9^h\ 30^m$, when strong positive sparks were obtained.

It appears from these instances, that thunder-storms in the neighbourhood of the place of observation are accompanied by extremely strong indications of atmospheric electricity, but that neither silent lightning nor the distant rumbling of thunder is accompanied by any marked effect on the electrometer.

For the sake of comparison with numerical data given in the former paper, applying to the six months October 1862 to March 1863, I subjoin the corresponding data for April to September 1863, thus completing a year from the commencement of observations.

	Positive only.	Negative only.	Both kinds.
	Days.	Days.	Days.
Rain	17	7	12
Snow	1	0	2
Hail	1	1	0
Fog	3	0	0
Thunder or lightning	2	2	3

There were 34 days on which both positive and negative electricity were observed; and on 29 of these, rain or other downfall occurred. The remaining 5 days, with the strongest negative observed, and the state of cloud and wind at the time, were as under (the scale for cloud being 0–10, and for wind 0–6).

May 31.	−0·4	10 nim.	1 S.W.
June 12.	−0·4	10 all sorts.	1 N.E.
July 6.	−0·1	7 { nim. intensely black.	4 { N.W. a brief squall.
July 15.	−0·8	10 st.	1 N.
Aug. 24.	−1·0	9 cu.-st.	1 S.W.

It will be observed that in all these instances the weather was cloudy and the negative electricity weak, characteristics which also belong to the corresponding instances in the former paper. The remark there made, that on every day on which negative electricity had been observed, positive had also been observed, holds good down to the present date (March 1864).

The monthly means of the results of fine-weather observations, for different hours of the day, from April to September 1863, are shown in the following Table. They have been computed in the same manner as the corresponding numbers in the former paper.

Hour.	April.		May.		June.		July.		August.		September.	
	Nr. of observations.	Mean.	Nr. of observations.	Mean.	Nr. of observations.	Mean.	Nr. of observations.	Mean.	Nr. of observations.	Mean.	Nr. of observations.	Mean.
6 to 7 A.M.	...	.....	...	...	1	2·20	2	3·80	1	3·39		
7 to 8	5	4·82	2	3·40	8	3·28	7	4·16	5	4·40	12	3·85
8 to 9	16	4·46	19	3·15	16	2·94	18	3·06	12	3·90	7	3·63
9 to 10	3	4·37	11	2·80	8	2·95	13	3·34	4	4·54	4	4·75
10 to 11	2	5·70	3	2·27	4	2·60	12	2·88	7	4·10	1	5·00
11 to 12	4	3·10	2	2·95	2	2·10	10	2·71	2	2·33		
12 to 1 P.M.	4	4·15	3	3·30	4	2·60	8	3·32	5	4·52	1	4·96
1 to 2	9	4·31	3	3·57	9	3·29	19	3·10	10	3·80	8	4·75
2 to 3	14	4·92	19	3·47	15	2·88	10	3·12	7	3·99	8	4·13
3 to 4	...	...	3	3·93	6	2·94	10	3·23	2	4·51	2	2·78
4 to 5	6	3·77	7	3·50	6	3·17	9	3·60	2	3·35	1	7·62
5 to 6	5	3·84	8	3·69	5	3·22	9	2·92	2	4·05	4	4·15
6 to 7	4	4·02	5	3·48	5	3·02	9	3·86	6	3·27		
7 to 8	3	3·50	3	3·83	3	3·10	6	2·33	6	4·75		
8 to 9	...	...	1	1·50	1	3·80	3	3·33	3	3·00	3	3·25
9 to 10	12	3·18	22	2·97	21	2·39	14	1·93	8	2·60	11	3·39
10 to 11	4	2·80	3	2·17	4	2·40	12	2·01	4	3·29	3	2·46
11 to 12 P.M.	2	3·35	6	1·70	3	2·97	1	2·90	3	1·96	1	2·80
12 to 2 A.M.	1	2·20	1	4·60	4	1·68	...	...	2	2·77		
Sums and means.	... 94	4·08	121	3·13	125	2·83	172	3·01	91	3·71	66	3·92

For the whole six months we have the following results:—

Hour.	Number of observations.	Mean of all observations.	Mean of monthly means.
6 to 7 A.M.	4	3·30	3·13
7 to 8	39	3·96	3·98
8 to 9	88	3·47	3·52
9 to 10	43	3·44	3·79
10 to 11	29	3·33	3·76
11 to 12	20	2·71	2·64
12 to 1 P.M.	25	3·64	3·81
1 to 2	58	3·69	3·80
2 to 3	73	3·70	3·75
3 to 4	23	3·33	3·48
4 to 5	31	3·64	4·17
5 to 6	33	3·51	3·64
6 to 7	29	3·55	3·53
7 to 8	21	3·51	3·50
8 to 9	11	3·11	2·98
9 to 10	88	2·71	2·74
10 to 11	30	2·40	2·52
11 to 12	16	2·33	2·61
12 to 2 A.M.	8	2·38	2·81
Means of columns	...	3·45	3·38

Hence there appears to be a maximum soon after sunrise, a decided minimum between 11 and 12, and a maximum (less clearly marked) between 4 and 5 P.M., followed by a regular decrease to midnight. These

results agree very well with those derived from the previous six months, allowing for the difference between the length of the day in summer and in winter.

The following Table of the variations of electricity in fine weather, from month to month, embraces the whole period of observation down to February 1864. These results, as well as those above given, are expressed in units of station electrometer with second fibre, being the same unit that was employed in the previous paper.

The day is supposed to be divided into three portions—before noon, noon to 6 P.M., and after 6 P.M. For each month, all the observations in each portion have been summed and divided by their number, giving the means shown below.

Year.	Month.	Before noon.	Noon to 6 P.M.	After 6 P.M.	Mean of three preceding columns.
1862.	October.	3·42	3·68	2·69	3·26
	November.	3·53	2·89	2·58	3·00
	a December.	4·09	5·01	2·77	3·96
1863.	January.	4·11	4·88	3·42	4·14
	February.	6·10	5·77	4·96	5·61
	March.	6·28	5·10	5·02	5·47
	April.	4·41	4·37	3·26	4·01
	May.	2·98	3·54	2·85	3·12
	June.	2·91	3·02	2·52	2·82
	b July.	3·17	3·20	2·50	2·96
	August.	3·98	4·01	3·20	3·73
	September.	3·98	4·41	3·18	3·86
	October.	5·24	4·16	2·74	4·05
	November.	4·24	4·13	2·82	3·72
	December.	4·51	5·14	3·39	4·35
1864.	January.	3·86	5·74	3·63.	4·41
	c February.	4·78	4·97	3·16	4·30

a. Second fibre put in December 6th.

b. Third fibre put in July 31st.

c. The electricity on February 17th and part of 18th was out of range, and has not been reckoned.

These results show that atmospheric electricity is stronger in winter than in summer, and seem to indicate a double maximum and minimum within the year,—the principal maximum occurring about February, and the other maximum about October; the principal minimum in June, and the other in November. It will be observed that in every case the numbers in the column "after 6 P.M." are the smallest.

At the suggestion of Professor Thomson, I have made a careful comparison of the states of electricity, as regards both strength and variableness, for different directions of wind. For this purpose I have tabulated according to direction of wind (separating also fine-weather from wet-weather observations) the daily entries of mean potential at 2 P.M. for the first twelve months, also the variableness as measured by the difference between the entries of highest and lowest potential for the same hour. Where there was no observation between 3 and 4 P.M. the day was passed over;

and where more than one observation was entered between these hours, that which was nearest to 2 P.M. was alone reckoned.

From these data, the monthly means of strength and variableness were computed; but in neither case was any regularity exhibited. The only results of this comparison which seem worthy of record are the annual fine-weather means (derived from the monthly) for the prevailing directions of wind. These are—

	Calm.	S.W.	N.	N.W.	W.
Strength	4·29	3·63	4·03	4·48	4·05
Variableness ..	1·19	·88	1·22	1·71	·79

I append, by way of specimen, the observations taken on June 29, July 1, 18, and 19. The first two days contain instances of some of the weakest electricity that I have ever found in clear weather (I allude particularly to the observations at $2^h\ 10^m$ June 29th, and at $3^h\ 47^m$ July 1st). The other two days afford fair instances of observations during thunder and lightning*.

	Electricity.			Rain.	Cloud.		Wind.		Barometer uncorrected.	Thermometers.	
	Mean.	Highest.	Lowest.		0–6.		0–10.			Dry bulb.	Dry above wet.
June 29.											
h m											
8 48 A.M.	+ 2·1	+ 2·2	+ 2·1	.....	0	.....	0	Calm.	30·05	67°8	3°8
2 10 P.M.	+ 0·5	+ 0·8	+ 0·2	.....	2	Cu.	2	N.	30·03	78·1	7·8
9 27	+ 1·8	+ 1·8	+ 1·7	.....	0	.....	0	Calm.	30·07	69·4	3·6
July 1.											
7 31 A.M.	+ 2·3	+ 2·3	+ 2·2	.....	0	.....	0	Calm.	30·12	62·5	2·5
8 20	+ 1·8	+ 1·9	+ 1·7	.....	0	.....	0	„	30·12	65·9	4·0
9 49	+ 1·8	+ 1·9	+ 1·6	.....	0	.....	0	„	30·11	70·4	7·1
3 47 P.M.	+ 0·8	+ 1·0	+ 0·5	.....	0	.....	1	S.W.	30·08	81·3	12·1
8 58	+ 1·6	+ 1·7	+ 1·4	.....	1	St.	0	Calm.	30·12	66·6	5·3
10 29*a*	+ 1·6	+ 1·6	+ 1·5	.....	0	.....	0	„	30·12	60·6	3·3
July 18.											
8 16 A.M.	+ 2·2	+ 2·3	+ 2·1	.....	1	Cu.	0	Calm.	30·28	68·2	1·9
11 58	+ 2·9	+ 3·0	+ 2·9	.....	5	Cu. & st.	0	„	30·28	77·5	4·3
1 51 P.M.	+ 3·6	+ 3·8	+ 3·4	.....	2	Cu.	1	N.W.	30·27	79·3	5·8
3 21*b*	− 24·3	−20·2	−27·6	.....	9	Nim.&cu.	1	N.W.	30·26	77·4	4·3
3 40	− 30·1	−26·9	−32·4	Moderate rain ...	9	„	...	.....	30·26	77·4	4·0
3 49	− 59·6	−43·9	−76·9	Pouring rain ...	9	Nim.	1	N.W.	30·27	76·0	3·2
3 59	− 90·2	.....		Light rain.							
4 0	−105·4										
4 1	− 80·3										
4 2	− 93·6										
4 3	− 86·8	Peal overhead.									
4 3½	− 49·4										
4 4	− 64·3										
4 6	− 74·2										
4 7	− 55·9		[head.	Rain heavy.							
4 8	− 1·2	Rumbling over-		[rate.							
4 9	− 19·5			Rain mode-							
4 10	+ 24·1										

a. Aurora.

b. Continuous rumbling of distant thunder in N.W., lasting till 5 P.M.

* The details of daily observations from April 1, 1863, to February 28, 1864, inclusive, are given in a series of Tables which are preserved for reference in the Archives.

TABLE (*continued*).

	Electricity.			Rain.	Cloud.		Wind.		Barometer uncorrected.	Thermometers.	
	Mean.	Highest.	Lowest.		0–6.		0–10.			Dry bulb.	Dry above wet.
July 18.											
h m											
4 10½ P.M.	− 18·5	Flash.									
4 11	− 45·7	Heavy peal.									
4 12	−111·0			[rate.							
4 12½	− 81·9	.....		Rain mode-							
4 14	−146·0	Flash.									
4 15	−138·0										
4 16	−120·0		[der.								
4 17	−107·0	Heavy thun-									
4 17½ *a*	−129·0	.....		Heavy rain.							
4 18	− 61·8	.....		Pouring							
4 19	− 74·2	.....		„ [rain.							
4 19½	− 80·0	.....		„							
4 20	− 62·7										
4 24	− 73·5										
4 25	+ 2·2										
4 33	− 53·2			[rain.							
4 34	− 65·2	.....		Pouring							
4 35	− 3·7	.....		„							
4 37	− 27·8	[tinuous.									
4 38	+ 4·6	Thunder con-									
4 39½	− 16·1										
4 40	− 80·7										
4 41	−101·0	[overhead.									
4 41½	+ 73·2	Heavy clap									
4 42	+ 46·4			[rate.							
4 43	+ 38·0	.....		Rain mode-							
4 44	+ 14·8	.....		Rain light.							
4 45	− 2·2										
5 8	+ 24·7	+25·9	+22·8	.....	...	.....	...	.....	30·28	74°·7	2°·8
6 7	+ 5·7	+ 5·8	+ 5·5	.....	6	Cu. &c.	0	Calm.	30·29	75·9	2·7
8 8	+ 3·8	+ 3·8	+ 3·8	.....	7	Cu.-st.&c.	0	„	30·30	75·4	2·7
10 0	+ 1·8	+ 2·0	+ 1·5	.....	9	Nim.	1	N.W.	30·30	69·2	1·3
The weather has been extremely oppressive all day. Amount of rain ·31 inch.											
July 19.											
9 49 A.M.	+ 6·1	+ 7·2	+ 5·0	.....	10	Nim.	1	N.	30·29	70·6	2·0
1 3*b* P.M.	+ 3·1	+ 3·5	+ 2·9	.....	3	Cu. & ci.	0	Calm.	30·23	76·3	3·5
Thunder and lightning in W. and N.W. Apparently raining there.											
3 11 P.M.	− 34·9	.....		....	9	Nim.&cu.	...	.....	30·20	74·2	2·9
3 12	− 38·3										
3 13	− 37·1										
3 16	− 20·7	.....		Raining.				[ing in N.W.			
3 22	− 23·5	.....		Not raining here, but thundering and apparently rain-							
3 32	− 17·0	Thundering in N.W.									
3 35	− 16·7	Flash in N.W.									
3 57	− 20·1	.....		....					30·20	75·6	3·0
4 12	− 9·9	Thunder in N.E.		.....	8	Nim.&cu.	2	N.			
9 18	+ 2·4	+ 2·8	+ 1·8	.....	10	Nim. &c.	0	Calm.	30·20	68·6	1·8

a. Continuous rumbling of distant thunder till 5 P.M., followed by occasional distant thunder till about 5h 15m P.M.

b. Excessively close.